RL-TR-96-185
Final Technical Report
November 1996

LANGLEY ADRI PRODUCTION SUPPORT (LAPS)

Synectics Corporation

Orest Mykolenko, Roger M. Reinhold, and James A. Sieffert

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

Rome Laboratory
Air Force Materiel Command
Rome, New York

This report has been reviewed by the Rome Laboratory Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be releasable to the general public, including foreign nations.

RL-TR-96-185 has been reviewed and is approved for publication.

APPROVED: James A. Sieffert
JAMES A. SIEFFERT
Project Engineer

FOR THE COMMANDER:
JOSEPH CAMERA
Technical Director
Intelligence & Reconnaissance Directorate

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	November 1996	Final Jan 95 - Oct 95

4. TITLE AND SUBTITLE

LANGLEY ADRI PRODUCTION SUPPORT (LAPS)

5. FUNDING NUMBERS

C - F30602-94-D-0066 T20
PE - 27431F
PR - R508
TA - QD
WU - 21

6. AUTHOR(S)

Orest Mykolenko, Roger M. Reinhold, and James A. Sieffert

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

PRIME:
Synectics Corporation
10400 Eaton Place, Ste 200
Fairfax, VA 22030-2208

SUB:
Environmental Research
Institute of Michigan (ERIM)
P.O. Box 134001
Ann Arbor, MI 48113-4001

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Rome Laboratory/IRRP
32 Hangar Road
Rome, NY 13441-4114

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

RL-TR-96-185

11. SUPPLEMENTARY NOTES

Rome Laboratory Project Engineer: James A. Sieffert/IRRP/(315) 330-2344

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The Environmental Research Institute of Michigan (ERIM) provided operator and supervisor instruction and other support for the operation of the Geocoded Imagery Production System (GIPS) at the 480th Intelligence Group (IG) at Langley Air Force Base, Virginia. ERIM also augmented the GIPS by developing and implementing new software applications to store and retrieve digital ground control point chips and to produce an ARC Digital Raster Imagery (ADRI) Product Catalog. ERIM populated the 480th IG's Digital Chip Library with existing digital ground control chips developed during Phase III of the ADRI Production Program.

14. SUBJECT TERMS ARC Digital Raster Imagery, ADRI, ARC Raster Chart, ARC, Satellite Pour l'Observation de la Terre, SPOT, Geocoded Imagery, georectified imagery, geopositioning

15. NUMBER OF PAGES 64

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

CONTENTS

FIGURES iii

TABLES iii

ACRONYMS iv

1.0 EXECUTIVE SUMMARY 1

2.0 OVERVIEW 2
  2.1 BACKGROUND 2
  2.2 PROJECT SCHEDULE 2

3.0 INSTRUCTION 4
  3.1 OPERATOR INSTRUCTION 4
    3.1.1 Description 4
    3.1.2 Lessons Learned 5
  3.2 SUPERVISOR INSTRUCTION 6
    3.2.1 Description 6
    3.2.2 Lessons Learned 6
  3.3 EXECUTIVE BRIEFING 6
    3.3.1 Description 6
    3.3.2 Lessons Learned 7

4.0 SUPPORT 8
  4.1 ON-SITE SUPPORT 8
    4.1.1 Description 8
    4.1.2 Details of Support Activities 8
    4.1.3 Lessons Learned 9
  4.2 TELEPHONE SUPPORT 10
    4.2.1 Description 10
    4.2.2 Lessons Learned 10
  4.3 ADRI SOFTWARE MAINTENANCE SUPPORT 10
    4.3.1 Description 10
    4.3.2 Lessons Learned 10
    4.3.3 System Problem Reports 10

5.0 DIGITAL CHIP LIBRARY APPLICATION 12
  5.1 SYSTEM ENGINEERING 12

CONTENTS (Continued)

5.2 DEVELOPMENT 12
5.3 TESTING 12
5.4 DOCUMENTATION UPDATES 13
5.5 DATABASE DEVELOPMENT 13
5.6 INSTALLATION AND INSTRUCTION 13
5.7 LESSONS LEARNED .... 13\

6.0 CATALOG APPLICATION 14
6.1 SYSTEM ENGINEERING 14
6.2 DEVELOPMENT 15
6.3 TESTING 15
6.4 DOCUMENTATION UPDATES 15
6.5 INSTALLATION AND INSTRUCTION 16
6.6 LESSONS LEARNED 16

7.0 MANAGEMENT 17
7.1 PROGRAM MANAGEMENT 17
7.2 PROGRAM REVIEW 17
7.3 MONTHLY STATUS REPORTS 17
7.4 ADRI MANAGEMENT AND ENGINEERING SUPPORT 17

8.0 DOCUMENTATION 18
8.1 DESCRIPTION 18
8.2 LESSONS LEARNED 18

9.0 FOLLOW-ON ACTIONS 20

10.0 REFERENCES 21

APPENDIX 22
A Developmental Roadmap for the Geocoded Imagery Production System (GIPS)

FIGURES

1. LAPS Schedule 3

TABLES

1. Documentation Provided for GIPS Training 4
2. GIPS Operator Instruction 5
3. On-Site Support Provided by ERIM 8
4. Final Status of SPRs 11
5. Documentation Provided 18

ACRONYMS

ACC	Air Combat Command
ADRI	ARC Digital Raster Imagery
AFB	Air Force Base
APPS	Analytical Photogrammetric Positioning System
ARC	Equal Arc-second Raster Chart/Map
CCT	Computer Compatible Tape
CD-ROM	Compact Disk-Read Only Memory
COTS	Commercial Off-The-Shelf
DMA	Defense Mapping Agency
DTED	Digital Terrain Elevation Data
EOD	Erasable Optical Disk
ERIM	Environmental Research Institute of Michigan
ERIPS	ERIM Remotely-Sensed Image Processing System
GCP	Ground Control Point
GIPS	Geocoded Imagery Production System
GIU	Geo-Image Unit
HRV	High Resolution Visual
IG	Intelligence Group
LAPS	Langley ADRI Production Support
MACS	Mapping Applications Client/Server
MCP	Map Control Point
POC	Point Of Contact
RL	Rome Laboratory
SCSI	Small Computer System Interface
SDT	Spatial Display Tool
SOW	Statement of Work
SPOT	Satellite Pour l'Observation de la Terre
SPR	System Problem Report
USAF	U.S. Air Force
ZDR	Zone Distribution Rectangles

1.0 EXECUTIVE SUMMARY

The Environmental Research Institute of Michigan (ERIM) provided operator and supervisor instruction and other support for the operation of the Geocoded Imagery Production System (GIPS) at the 480th Intelligence Group (IG) at Langley Air Force Base, Virginia under Contract ERI-92-PI-20. The Langley ARC (Arc Raster Chart) Digital Raster Imagery (ADRI) Production Support (LAPS) program covered the period January 1995 through September 1995 and was a follow-on activity to the GIPS program.

ERIM also augmented the GIPS by developing and implementing new software applications to store and retrieve digital ground control point chips and to produce an ADRI Product Catalog. ERIM populated the 480th IG's Digital Chip Library with existing digital ground control chips developed during Phase III of the ADRI Production Program.

The GIPS is composed of Commercial-Off-The-Shelf (COTS) hardware components, COTS software packages, and non-developmental software packages designed to provide the production environment and tracking tools necessary to process and deliver ADRI products. It was developed and delivered under GIPS program, Contract ERI-92-PI-07.

Synectics Corporation was the prime contractor for this project.

2.0 OVERVIEW

2.1 BACKGROUND

The U.S. Air Force (USAF) established the ADRI program in 1990 in recognition of the utility of an unclassified, broad area, current database of imagery to support mission planning. The ADRI image databases are used in mission planning and theater battle management systems as an image backdrop to assist mission profile development, a means to provide geopositioning information for navigation and target area acquisition, and a real-world scene for perspective view generation and mission preview. The 480th IG has the responsibility for the production of ADRI for the Air Combat Command and maintenance of the ADRI Product Catalog.

This final report covers the work performed by ERIM on the LAPS program, which consisted of four major activities: (1) Instruction, described in Section 3; (2) Support, described in Section 4; (3) Digital Chip Library Application, described in Section 5; and (4) Catalog Application, described in Section 6. Each of these sections addresses lessons learned. Section 7 and Section 8 contain information about program management procedures and documentation.

2.2 PROJECT SCHEDULE

In January 1995 we received authorization for LAPS (follow-on activity to the GIPS program). We received the formal contract on 27 April. Seven weeks of on-site operator instruction began on 6 March and was completed on April 21, at which time the GIPS operators received course completion certificates. Two weeks of supervisor instruction followed operator instruction, and was completed on May 5. On 10 May we held an Executive Briefing. We provided five weeks of on-site support immediately following the training. We provided 3.5 additional one-week support sessions over the remainder of the contract term. The schedule is shown in Figure 1.

The last part of the operator instruction was a three-day contingency exercise. The exercise took two additional days to complete, which overlapped the first week of supervisor instruction. Additional alterations in the schedule involved delays in delivery of the Digital Chip Library and the program review due to the 480th personnel visiting Eagle Vision in Germany the week of 26 June. This schedule change caused a one-month delay in delivery of the GIPS documentation, in order for ERIM to incorporate changes to the documentation that resulted from installation of and training on the Digital Chip Library and Catalog Applications.

On 11 September 1995 we requested an extension in the period of performance through 31 October 1995. The additional time was requested to complete activities for which we required Government direction, which included scheduling and conducting the final program review and performing assignments that were part of the ADRI management and engineering support task, and preparing the final report. The 28 June program review, which was postponed, was held on 23 October.

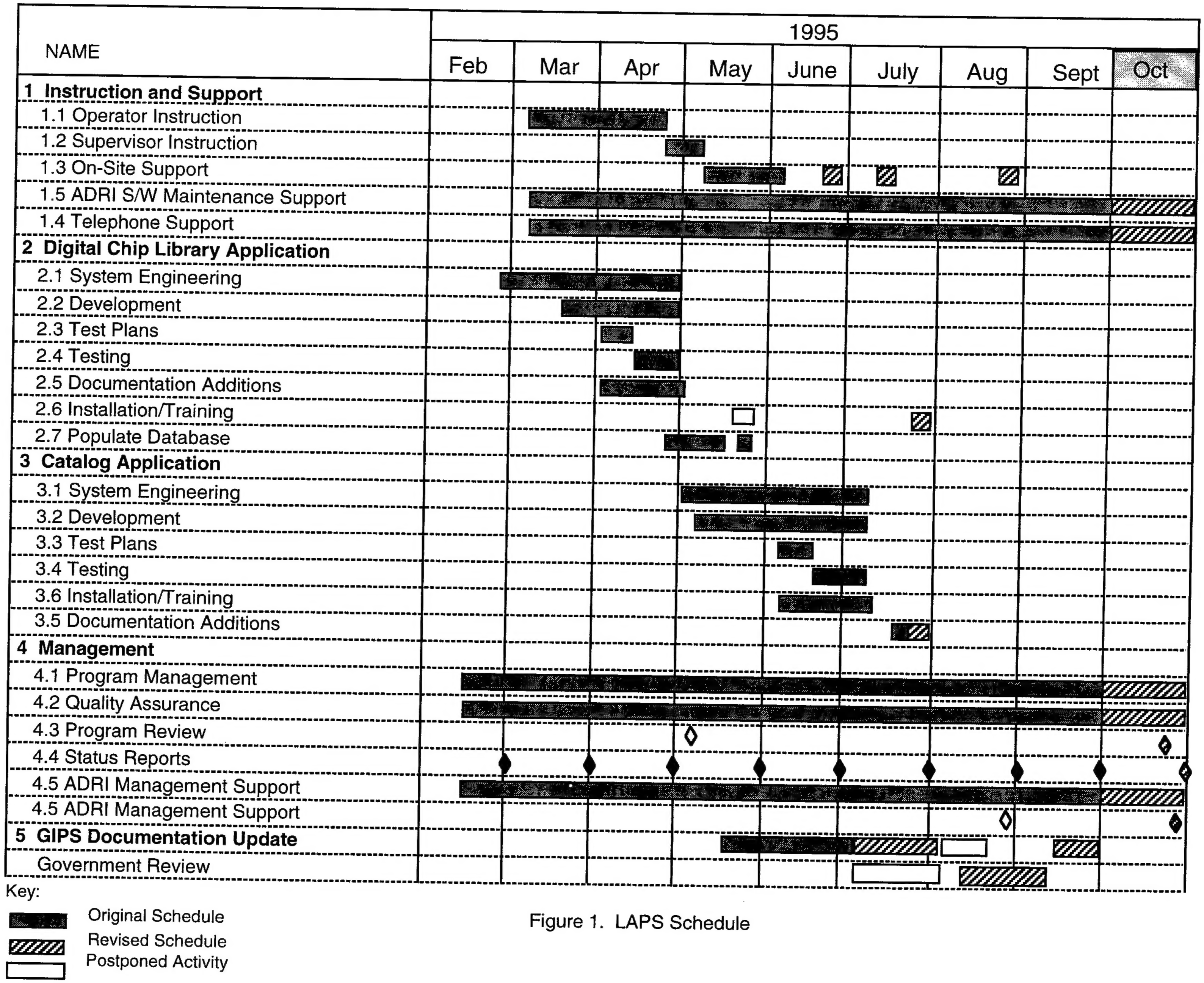

Figure 1. LAPS Schedule

3.0 INSTRUCTION

3.1 OPERATOR INSTRUCTION

3.1.1 Description

ERIM provided seven consecutive, 40-hour weeks of GIPS operator instruction at Langley AFB. Two ERIM people were on site at Langley AFB for the duration of the seven weeks of instruction. The on-site individuals rotated during the seven weeks.

Instruction was provided to four operators and two supervisors. ERIM provided each operator and supervisor a hard copy of all of the GIPS user documentation (with the exception of the COTS manuals) at the beginning of the instruction session. This set of documentation was the same draft set provided under the GIPS project and is listed in Table 1. We recorded all user comments during the instruction session and used those comments to update the documentation later in the program.

Table 1. Documentation Provided for GIPS Training

Document Title
ADRI Operator Orientation Documentation, V 2.0
ADRI Operator Orientation Exercises, V 2.0
ADRI Quality Assurance Manual, V 2.0
ADRI Production Procedures, V 3.0
ADRI Production Database System, V 2.0
ADRI Production Support System User's Guide, V 2.0
GIPS Interface Requirements Specification, Volume 1: GIPS External Interfaces, V 1.0
GIPS Interface Requirements Specification, Volume 2: Ground Control Interface Control Document, V 1.0

The goal of the operator instruction was to make operators proficient in the production of ADRI products and enable them to update ADRI specification-compliant zone distribution rectangles (ZDR). Approximate instruction time for the seven weeks of instruction is presented by task in Table 2. The original schedule was maintained to within four hours for the duration of the instruction except for the contingency exercise, which ran over by 12 hours.

On the second day of training, when one of the Seagate Elite-9 disk drives failed, ERIM's on-site training personnel performed initial diagnostic and corrective actions on the drive but were unable to correct the problems and decided that it had to be replaced. ERIM contacted StorNet, the distributor of the Elite-9 disk drives, and they provided a replacement drive under warranty within 24 hours. The faulty disk drive had been attached to the GIPS 20a Sun Sparc 20, which was without an external disk drive for about three days overall. However, during this period it was still operational and used for the operator training.

Table 2. GIPS Operator Instruction

Instruction Task	Approximate Instruction Time (hours)
ADRI Production Flow	2
ARC/INFO Applications	6
ERIPS Applications	11
Database Applications	11
Preprocessing	22
Radiometric Balancing	28
Control Point/Chip Preparation	40
Block Adjustment	28
Resampling	12
Mosaicking	12
Overview Image Creation/Error Analysis	12
ZDR Production	16
Accuracy Assessment	4
Final Production	12
ZDR Revision	40
Contingency Exercise	24
Total	280

3.1.2 Lessons Learned

ERIM instructors assumed a certain level of experience within the UNIX environment on the part of the operators. However, early in the instruction period, we found that the level of experience with UNIX varied within the group of trainees. A few of the operators had minimal or unrelated experience. To address the problem, ERIM provided an hour of instruction in UNIX commands. For future classes, instructors will assess experience in prerequisites prior to training, and plan and provide instruction accordingly.

As part of the decision to hold the instruction at Langley AFB, we were assured that normal 480th IG activities would not interfere with the training and that the trainees would be available and committed for the duration of the training. The 480th IG management did an excellent job of isolating the trainees from the day-to-day activities and ancillary assignments. Full management support, as provided by the 480th IG, was essential to the success of the instruction.

At the start of the training, one of the operators left the class due to poor health, then later returned to the class. The consequence is that he did not receive training on all of the applications. We recommend that a trainee who cannot attend the entire training course be dropped from the class altogether and scheduled to attend a future training course.

The data sets used for the contingency exercise covered an area that contained few cultural features. The operators took an inordinate amount of time to select points on these scenes as they relied on point selection criteria from target acquisition training received under a different program. This caused an overrun of 12 hours for this segment of the instruction.

For each week of operator instruction, a teaching assistant (TA) was assigned along with the instructor. This worked very well in both lecture and on-station sessions. The TA augmented the instructor in areas of expertise, and fielded questions especially during on-station sessions, which provided a wider knowledge base for the trainees.

The class size of six trainees worked very well. The class should have a maximum of two trainees per available workstation.

3.2 SUPERVISOR INSTRUCTION

3.2.1 Description

ERIM provided two supervisors with two consecutive, 40-hour weeks of GIPS supervisor instruction at Langley AFB. One ERIM person was on site for the duration of the two weeks of instruction. Both supervisors had previously participated in the operator instruction where they had received a hard copy of all of the GIPS user documentation (with the exception of COTS manuals). The supervisors' comments were compiled with operators' comments, which we later used to update the documentation.

The goal of the supervisor instruction was to make 480th IG supervisors proficient in the management of ADRI production and the ADRI Production Database System.

3.2.2 Lessons Learned

The supervisor instruction is designed to follow the operator instruction at the same time that the operators are beginning production. At that time, they have a real-world project and are becoming productive as a unit. While the operators begin their first project, they have additional technical questions which can interfere with the supervisor instruction. During the supervisor instruction, ERIM should provide a support person to assist the operators while the supervisors are learning the functions specific to their duties.

3.3 EXECUTIVE BRIEFING

3.3.1 Description

ERIM conducted an Executive Briefing, which was a one-day course for upper-level management whose purpose was to introduce upper-level 480th IG management to the GIPS and its capabilities. ERIM developed a briefing package for this session.

The Executive Briefing was held at the 480th IG, on 10 May. Attendees at the briefing included Jim Sieffert of RL/IRRP; Neil Sunderland of the 497th IG/INT; Bill Carlton, Courtney Meek, Kim Vaughn, Albert Franks, Ramona Montgomery, Karen Hines, and Kevin Koppenhaver of the 480th IG; and Joe Christy, Ken Nixon, and Roger Reinhold of ERIM. All participants were provided with copies of the Executive Briefing materials. Presenters included Jim Sieffert, Roger Reinhold, Joe Christy, Ken Nixon, and Bill Carlton. The briefing included an overview of the ADRI product and production process, an overview of the GIPS, a review of the GIPS schedule and deliverables, several live demonstrations of the system by 480th IG personnel, an overview of the ADRI database and archives, and discussions regarding the support and maintenance of the system.

3.3.2 Lessons Learned

The list of attendees changed a few times from the time of the inception of the Executive Briefing to the actual presentation. The final group of attendees did not include many individuals from the upper-level management of the 480th IG as first intended. The change of audience from what was initially planned resulted in additional preparation time, which increased the effort involved.

4.0 SUPPORT

4.1 ON-SITE SUPPORT

4.1.1 Description

ERIM provided eight weeks plus three days of on-site support at Langley AFB during the remaining contract term following the nine weeks of operator and supervisor instruction. The on-site support covered a five-week period after the conclusion of the supervisor instruction and was followed by a series of support visits scheduled at mutually agreed-upon times over the next three months. Table 3 shows support periods and ERIM individuals who provided support.

Table 3. On-Site Support Provided by ERIM

Five-Week Follow-On	
J. Christy	8–19 May
K. Nixon	22 May–2 June
J. Christy	5-9 June
Support Visits	
R. Stephenson	19–23 June
K. Nixon	5–7 July
K. Nixon, S. Kapolka	28 August–1 September

4.1.2 Details of Support Activities

During the week of 8 May, the support activities included:

- Assisting the operators in preparing for their system demonstration to Lt. Col. Chapin and representatives of the Defense Mapping Agency (DMA), and
- Supporting and attending a two-day meeting between the 480th IG and representatives of the DMA.

During the week of 15 May, activities included:

- Assisting Kim Vaughn organize the GIUs that the 480th IG had received from DMA and determining which would be sent to DMA for control,
- Helping the operators work through minor procedural and start-up issues,
- Reviewing the classified sections of the GIPS Interface Requirements Specifications with Kevin Koppenhaver, Ramona Montgomery, and Kim Vaughn.

During the weeks of 22 May and 29 May, on-site support activities included:

- Ensuring and assisting in the establishment of weekly system and database backups,
- Assisting in the reconstruction of information on previously delivered 480th IG ZDRs and Volumes,
- Identifying duplicate information in the database and assigning it to a "duplicate" region and the "hold" project,
- Assigning Country Codes and region names to unprocessed GIUs,

- Tracking actual versus planned production schedules,
- Reviewing the ZDR proof print books with Kevin Koppenhaver and Kim Vaughn, and
- Reviewing a volume of 10 ZDRs of the Bosnian region produced by Eagle Vision.

During the week of 5 June, the normal on-site support activities included:

- Accelerating production,
- Verifying previously controlled geo-image units (GIUs),
- Supporting selection of control and tie points,
- Assisting the first radiometric balancing of the Algeria region,
- Reviewing an Eagle Vision ADRI volume, and
- Tracking actual versus planned production schedules.

At the request of the 480th IG, the week of 19 June was the first week of the mutually agreed-upon times. The on-site support activities during that week included:

- Reviewing block adjustment procedures with Kim Vaughn and Karen Hines,
- Supporting the block adjustment processing of central Algeria, and
- Introducing Catherine Cade to control point procedures. Catherine Cade had been designated to take over Kim Vaughn's responsibilities.

On-site support from 5 to 7 July included:

- Loading the Excel Production Tracking spreadsheets onto a DOS PC,
- Populating the spreadsheets with projections and actuals,
- Training Kim Vaughn and Catherine Cade in the use of the spreadsheets,
- Reviewing current production and planning,
- Reviewing 480th IG SPR action items, and
- Documenting operator on-station time.

On-site support from 28 August to 1 September included:

- Reviewing the Production Planning and Quality Assurance records of the Bright Star exercise,
- Observing and assisting when necessary with the Bright Star ZDR production and final review,
- Updating the ADRI Production Database with 8-mm dupe labels and accuracy corrections from the ADRI Phase II and III programs,
- Reviewing the operation of the autocorrelator,
- Explaining the use of the autocorrelator parameter settings,
- Reviewing current and near-term production and planning,
- Reviewing 480th IG SPR action items, and
- Reviewing operator on-station time.

4.1.3 Lessons Learned

Prior to the beginning each week of on-site support, ERIM and the 480th IG mutually identified the support objectives for the upcoming week. This technique helped define and focus the support activities.

Within five months of the completion of training, two of the trained operators were assigned to positions outside of the 480th IG. As a result of personnel changes, we provided their replacements with some training as part of the on-site support. Given the turnover rate we experienced during this program, we would recommend a yearly training schedule to accommodate new operators.

We also provided some refresher training to trained operators as part of on-site support. We would recommend yearly refresher training.

4.2 TELEPHONE SUPPORT

4.2.1 Description

ERIM provided telephone ADRI production support for the term of the contract. This support was used in the event the 480th IG encountered any problems related to the GIPS, or if the 480th IG personnel had an ADRI-related production issue or problem. We provided the 480th IG with the name and telephone number of both a primary and a secondary point of contact (POC) at ERIM to call for assistance from 08:00 to 17:00 EST, Monday through Friday.

During the first three months of the program, we averaged 22 hours of telephone support per month, due to the assistance provided by on-site personnel. During the remaining five months, we provided an average of 50 hours of support per month.

4.2.2 Lessons Learned

We provided the 480th with considerably more telephone support for operating system and hardware items than we had planned. In the future, we will budget more time for this type of support. Overall, telephone support as expected proved very useful.

4.3 ADRI SOFTWARE MAINTENANCE SUPPORT

4.3.1 Description

ERIM provided software maintenance support for the ADRI-specific software for the term of the contract. This software maintenance was in the form of telephone support, System Problem Report (SPR) tracking, and software "bug" fixes. During the first three months we averaged 36 hours of support per month. During the remaining five months we averaged 19 hours of support per month.

As part of the support, we delivered six software updates. One was delivered electronically via the Internet and the remainder via 8-mm tape. A letter accompanied each update, explaining the problems being addressed, the solutions, the installation procedure, and the validation procedure.

The 480th IG electronically uploaded the SPRs to ERIM.

This task did not cover maintenance and support of the ERIM Remotely Sensed Image Processing System (ERIPS) software. The first year of software maintenance is included in each license.

4.3.2 Lessons Learned

The electronic uploading of SPRs and downloading of software updates was very helpful.

John Stelyn, an experienced on-site system administrator, helped resolved system problems quickly and efficiently.

4.3.3 System Problem Reports

ERIM used an SPR procedure based on an Oracle tool that recorded, tracked, and reported the system problems. Table 4 summarizes the SPRs with the counts indicating total numbers:

Table 4. Final Status of SPRs

Category	**Status**	**Final Totals**
Documentation	Completed	2
Enhancements	Holding	18
	Completed	1
Hardware	Completed	4
	Awaiting additional information	1
Operating System	Assigned	1
	Completed	8
	Rejected—a non-problem	1
Software	Assigned	2
	Completed	22
	Delivered—awaiting validation	0
	Further study	2
	Not reproducible	5
	Open—not assigned	1
	Ready for retest	1
	Rejected—a non-problem	2
Total		**71**

5.0 DIGITAL CHIP LIBRARY APPLICATION

5.1 SYSTEM ENGINEERING

ERIM developed and implemented a software application that provides the necessary tools for sorting and storing digital ground control chips created by the ERIPS software on Erasable Optical Disk (EOD) media. The application also provides the necessary tools for retrieving these digital ground control chips from EOD media based upon a list of ground control points in the ADRI Production Database System. This Digital Chip Library can be used to retrieve ground control for new images for ADRI processing wherever ground control has been previously measured and placed in the library.

This software reads ERIPS ground control point image chips and headers, and sorts them onto EODs by latitude and longitude boxes. The EOD location of each chip is stored in the ADRI Production Database System. To retrieve a ground control point chip, the operator uses a GIPS ARC/INFO application to "point-and-click" at ground control points plotted in an ARC/INFO window. The chip of the selected point, its label, and its geographic coordinates are then displayed on the screen.

5.2 DEVELOPMENT

The Digital Chip Library Application software was developed at ERIM's facility in Ann Arbor, Michigan on a Sun Sparc 20 computer system running the Solaris 2.3 operating system. ERIM tailored the ADRI Production Database System as required for the Digital Chip Library Application. We delivered the software to the Government in the form of source and object code.

ERIM conducted all systems engineering activities required to design and integrate the Digital Chip Library Application into the GIPS at the 480th IG. This activity included a requirements definition and review. ERIM defined and documented the interface requirements including:

- Ground control point chips from ERIPS,
- ADRI Production Database System, and
- ARC/INFO.

The delivery, installation, and training of the Digital Chip Library Application and data were scheduled for the last week of June to correspond with the anticipated program review.

5.3 TESTING

ERIM prepared internal test plans for the Digital Chip Library Application. ERIM's ADRI production staff and engineering staff reviewed and approved the test plans and test preparations to ensure that the Digital Chip Library Application was adequately tested. ERIM executed the internal test plans for the Digital Chip Library Application in order to validate operation of the application.

On 6 July, ERIM delivered a draft copy of the Acceptance Test Plan for the Digital Chip Library Application to Jim Sieffert of RL/IRRP and Bill Carlton of the 480th IG. Prior to delivering the Digital Chip Library Application to the 480th IG, ERIM executed the Acceptance Test Plan on a system at ERIM. ERIM executed the Acceptance Test Plan after installation of the Digital Chip Library Application at the 480th IG.

5.4 DOCUMENTATION UPDATES

ERIM updated ADRI Operator Orientation Documentation to include the Digital Chip Library Application. ERIM provided eight copies of these materials at the time of the instruction on the new application.

ERIM updated, modified, and/or provided supplements to the specific GIPS documentation impacted by the development of the Digital Chip Library Application. We updated the new Digital Chip Library Application documentation and training materials to incorporate changes that resulted from installation of and training on the Digital Chip Library.

5.5 DATABASE DEVELOPMENT

Using the Digital Chip Library Application, we prepared and populated the database with 16,431 digital ground control chips which had been developed during Phase III of the ADRI Production Program. We encountered no problems in the application. The time required for preparation of the chips was about two hours per 1000. Most of this time was spent mounting and unmounting the EODs. The metadata describing the current inventory of ground control points in the ADRI database are cross-referenced with the available digital ground control chips. ERIM verified the 15-disk Digital Chip EOD Library and archived it on 8-mm tape.

5.6 INSTALLATION AND INSTRUCTION

The training materials and the installation plan for the Digital Chip Library were completed on time for delivery the week of 26 June. However, because the 480th IG personnel were not available that week, the delivery, installation, and training of the Digital Chip Library Application and data were rescheduled to the week of 24 July when all 480th IG personnel would be available to support the installation and execution of the Acceptance Test Plan and training.

During the week of 24 July, we delivered and installed the Digital Chip Library and Application, executed and passed the on-site Acceptance Test Plan, and trained the 480th IG personnel. During the training we encountered a media problem with one of the Digital Chip Library EODs. With John Stelyn's assistance, we were able to correct the problem and recover the data. While on-site for the installation of the Digital Chip Library Application, ERIM instructed GIPS personnel in the use of the Digital Chip Library application.

5.7 LESSONS LEARNED

This activity went as expected.

6.0 CATALOG APPLICATION

6.1 SYSTEM ENGINEERING

ERIM developed and implemented applications that: (1) retrieve ADRI metadata from existing ADRI 8-mm tape volumes, (2) interface data from the ADRI Production Database System to the Mapping Applications—Client/Server (MACS) Spatial Display Tool (SDT), (3) build printable ADRI catalog pages with cartographic backdrops using MACS, and (4) incorporate those pages with other textual information into an ADRI product catalog using a COTS word processing package, FrameMaker.

The applications automatically retrieve ADRI metadata and extract geographic coordinates of image extents of ADRI ZDRs in order to provide accurate information in the ADRI catalog. The applications use published ADRI 8-mm tape volumes as the input which enables the 480th IG to build catalog pages for any ADRI volume regardless of its publisher.

The applications, based on the ADRI Production Database System, retrieve volume and ZDR metadata, the geographic coordinates of image extents of ADRI ZDRs, and the ZDR sequence numbers relative to a volume automatically from an ADRI 8 mm volume. The metadata include information needed for the catalog such as:

- Total number of bytes in the Volume,
- Tile Map indicators for each ZDR,
- Accuracy data for each ZDR (if not already in the ADRI database),
- Total number of bytes in each ZDR, and
- Number of non-zero pixels in each ZDR (to calculate square kilometers).

Metadata not currently residing in the ADRI Production Database System for a volume and its ZDRs, are inserted into it. The retrieved information is then output in an ASCII file using the MACS SDT Saved Objects format. This file can then be directly loaded into the MACS SDT application for display.

Using existing MACS tools, ERIM provided a capability for creating printable ADRI catalog pages from the volume and ZDR information, which can then be printed on a postscript-compatible printer. The ADRI ZDR coverage statuses of "current," "obsolete," or "void" are visually distinguishable from each other when geographically displayed, and each ADRI ZDR coverage is outlined, regardless of the ZDR's status. Each ADRI ZDR coverage is annotated with its ZDR sequence number. The ADRI coverages can be printed with cartographic backdrops using existing MACS tools and databases (e.g., Digital Chart of the World).

Using FrameMaker, a capability was provided to ingest each of the postscript pages into the ADRI catalog document, to add textual information in both a header and a footer on each catalog page, and to prepare a title page and table of contents.

FrameMaker can also ingest volume and ZDR metadata tables prepared by the ADRI Production Database System. This capability enables textual pages to be printed that contain additional metadata that describe the ADRI volumes and provide a ZDR cell index.

ERIM conducted all systems engineering activities required to design and integrate the Catalog Application into GIPS at the 480th IG, including a requirements definition and review. ERIM defined and documented the interface requirements including:

- ADRI 8-mm tape cartridge volumes,
- ADRI Production Database System,
- MACS SDT Saved Objects format, and
- FrameMaker.

6.2 DEVELOPMENT

The Catalog Application was developed at ERIM's facility in Ann Arbor, Michigan, on a Sun Sparc 20 computer system running the Solaris 2.3 operating system. ERIM tailored the ADRI Production Database System as required for the Catalog Application. We delivered the software developed under this subtask to the Government in the form of source and object code.

We successfully installed a beta version of the MACS for Solaris 2.3 at ERIM. We used it for development of the Catalog Application.

On 24 March, Heidi Metzger of ERIM met with Jim Sieffert, Jeff Hanson, and Ray White at Rome Laboratory to discuss the Catalog Application. The discussions included requirements, operator procedures, training, and in general how MACS and ARC/INFO would be used to produce the ADRI catalog.

The Catalog Application development was scheduled to begin in May. However, to allow for Jeff Hanson's participation, the meeting was held early. Mr. Hanson was the government's primary contact for MACS, and he was leaving the government on 15 April. The success of this task was very dependent on the Government providing adequate support for MACS.

Advance work on the design of the Catalog Application included using ARC/INFO to vectorize a ZDR using a source map. A requirements review was held for the Catalog Application. The installation, acceptance test, and training of the Catalog Application were scheduled for the week of 24 July to coincide with the delivery of the Digital Chip Library.

6.3 TESTING

ERIM prepared internal test plans for the Catalog Application. ERIM's ADRI production staff and engineering staff reviewed and approved the test plans and test preparations to ensure that the Catalog Application was adequately tested. ERIM executed the internal test plans for the Catalog Application in order to validate operation of the application.

On 6 July, ERIM delivered a draft copy of the Acceptance Test Plan for the Catalog Application to Jim Sieffert of RL/IRRP and Bill Carlton of the 480th IG. Prior to delivering the Catalog Application to the 480th IG, ERIM executed the Acceptance Test Plan on a system at ERIM. ERIM executed the Acceptance Test Plan after installation of the Catalog Application at the 480th IG.

6.4 DOCUMENTATION UPDATES

ERIM developed new ADRI Operator Orientation Documentation to include the Catalog Application. ERIM provided eight copies of these materials at the time of the instruction on the new application.

ERIM updated, modified, and/or provided supplements specific to the GIPS documentation impacted by the development of the Catalog Application.

We updated the documentation and training materials to incorporate changes that resulted from installation of and training on Catalog Applications.

6.5 INSTALLATION AND INSTRUCTION

During the week of 24 July, we delivered and installed the Catalog Application, executed and passed the on-site Acceptance Test Plan, and trained the 480th IG personnel. ERIM also installed FrameMaker and MACS on the GIPS hardware. In-depth instruction on FrameMaker was not provided.

Overall, installation and training were well received and went smoothly. As planned, the installation took about a day and a half. We had scheduled two and a half days of training. However, the training took only two days, so the extra half day was used to provide training to two new GIPS operators, Jay Stokes and Kevin Sackey. Their training included an introduction to ADRI and preprocessing. As part of the preprocessing training they loaded all of the BrightStar images. Also, as planned, the fifth day was used to plan for the update of the Digital Chip Library with the 480th IG's Digital Chips and to perform post-installation validation and cleanup.

During the installation several problems were encountered and resolved. First, the free swap space was increased on GIPS 20a to resolve an Oracle problem. Next, we determined that the MACS does not run on a 24-bit display, a problem that was resolved by changing the operator log-on procedure on GIPS 20a. We also determined that the Catalog Application made use of a capability that is part of the GRID add-on module to ARC/INFO, for which the 480th IG did not have a license. Without a license, the 480th was unable to execute a critical step of the catalog generation process. This was temporarily resolved by obtaining a 10-day license from ESRI, which allowed us to complete the delivery, installation, and training. After consulting with the Government, we permanently resolved this problem by obtaining a license under this task for the 480th for the GRID module to ARC/INFO, which was installed at the 480th IG by John Stelyn.

We encountered some unexpected problems leading up to the purchase of the ARC/INFO GRID license from ESRI. The initial license quotations were substantially higher than what we had expected from previous experience. After several inquiries we determined that ESRI was not quoting us government pricing. It took several additional inquiries to convince ESRI to provide us with a quotation for the license using Government pricing. The purchase order to ESRI had to be accompanied by a letter stating that the license was being purchased under a Government contract for delivery to the Government.

6.6 LESSONS LEARNED

In the future, we should ensure that ARC/INFO modules used in the development environment are also available in the target environment. Also the 480th IG should be provided with training in the use of MACS.

The government should have installed MACS prior to ERIM's installation of the Catalog Application. This would have uncovered the problem with the 24-bit display.

7.0 MANAGEMENT

7.1 PROGRAM MANAGEMENT

ERIM managed all aspects of the LAPS program. ERIM supplied the necessary resources to efficiently manage the program and bring it to a successful conclusion.

7.2 PROGRAM REVIEW

The program review was held at the 480th IG on 23 October. Attending the review were Jim Sieffert of RL/IRRP; Bill Carlton, Daniel Saxon, Ramona Montgomery, and John Stelyn from the 480th IG; and Neil Sunderland from the 497th IG/INT.

The program review included an overview of the program, a review and update of hardware maintenance schedules, and a review and update of the software maintenance schedules and costs. As part of the program review, we reviewed with the Government the technical roadmap for enhancing the existing GIPS with new sensors and products.

7.3 MONTHLY STATUS REPORTS

ERIM prepared and electronically submitted monthly status reports via the Internet.

7.4 ADRI MANAGEMENT AND ENGINEERING SUPPORT

We provided ADRI management and engineering support to the U.S. Air Force for the contract term. This included:

- Support and attendance at the 10 May 1995, GIPS Executive Briefing at the 480th IG,
- Support and attendance at the 11 May 1995 meeting with the Defense Mapping Agency,
- Review of the Memorandum of Agreement prepared by the Defense Mapping Agency,
- Identification and documentation of possible duplicate deliveries from SICORP,
- Development of a Technical Roadmap, and
- Review of the Technical Roadmap at the 23 October program review.

The Technical Roadmap was the most significant part of the support effort of this subtask. Documents relating to this support are included in the Appendix of this volume.

We delivered a draft of the roadmap document to Bill Carlton of the 480th IG on 18 September. The roadmap document supports the 480th IG, which is considering acquiring new kinds of sensor data and incorporating those data into the 480th IG's GIPS for conversion into mission planning products. They are specifically considering data from the Landsat Thematic Mapper (TM); the ERS-1 and ERS-2 radar systems; the Indian Remote Sensing (IRS) IRS-1B and IRS-1C systems (IRS-1C launch expected late 1995); and the Canadian RadarSat system (launch date September 1995).

The document addressed the following five elements: (1) a summary of the processes required to enhance the GIPS software configuration; (2) a discussion of potential mission planning products that might be developed from the new sources of imagery (including any relevant products previously developed for the Department of Defense); (3) a summary of some of the potential exploitation platforms (and their limitations) to demonstrate the utility of the new sensors and products to the mission planning community; (4) a discussion of the training or support required to make effective use of any new capabilities within the GIPS; and (5) a timeline for implementation.

8.0 DOCUMENTATION

8.1 DESCRIPTION

ERIM provided eight copies of all existing GIPS user documentation (with the exception of the COTS manuals) for the operator and supervisor instruction activities. This documentation includes the *ADRI Production Support System User's Guide, ADRI Production Database System User's Guide, ADRI Production Procedures, ADRI Quality Assurance Manual, GIPS Interface Requirements Specification, ADRI Operator Orientation Documentation,* and *ADRI Operator Orientation Exercises.*

ERIM developed new *GIPS Executive Briefing* materials for a one-day course for upper-level managers. ERIM provided 12 copies of the *GIPS Executive Briefing* materials at the time of the one-day course.

ERIM updated *Operator ADRI Operational Guide* materials for the two new GIPS applications. ERIM provided eight copies of each of these *ADRI Operational Guide* materials at the time of the instruction on the new applications.

ERIM updated, modified, or provided supplements to the specific 480th IG ADRI production process documentation during the Langley ADRI Production Support activity. All of the GIPS user documentation was re-submitted in draft form following the completion of the last of the instruction activities (Catalog instruction). The Government was given the opportunity to review the documents after receipt of the draft copies. Two final copies were provided within 30 days after receipt of the Government's comments. ERIM also provided two soft copies of the final documentation in FrameMaker format. All documents were delivered on time.

A complete list of all GIPS documentation provided by ERIM is presented in Table 5.

Table 5. Documentation Provided

Document
Revised ADRI Quality Assurance Manual
Revised ADRI Operator Orientation Documentation
GIPS Executive Briefing
Revised ADRI Production Procedures
Revised GIPS Interface Requirements Specification (2 volumes)
Revised ADRI Production Database System User's Guide
Revised ADRI Production Support System User's Guide
Revised ADRI Operator Orientation Exercises

8.2 LESSONS LEARNED

The Orientation documentation did not have page numbers, which made it difficult to reference. Page numbers have been added to all documents.

No instructor guides exist for the ADRI Operator Orientation Exercises. An Instructor Guide should be developed.

One edit master copy for each deliverable document was available for the duration of the instruction. All proposed edits were annotated in these volumes. This proved to be an effective method for recording proposed changes.

Binding each document into a separate book made it easier for the instructors and trainees to use.

9.0 FOLLOW-ON ACTIONS

As follow-on actions, we recommend that the Government continue hardware maintenance; software maintenance for ARC/INFO, Oracle, and ERIPS; ADRI Production Telephone Support and ADRI Software Support; operator refresher training; and new operator training.

10.0 REFERENCES

Electronic Systems Center, Military Specification *Broad Area ARC Digital Raster Imagery (ADRI) Product,* MIL-B-89031, 24 July 1992.

Electronic Systems Center, Military Specification *ARC Digital Raster Imagery (ADRI) Format,* MIL-A-89027, 24 July 1992.

APPENDIX

A Developmental Roadmap for the Geocoded Imagery Production System (GIPS)

A DEVELOPMENTAL ROADMAP FOR THE

480TH INTELLIGENCE GROUP'S

GEOCODED IMAGERY PRODUCTION SYSTEM (GIPS)

18 SEPTEMBER 1995

CONTENTS

Figures 26
Tables 26
Acronyms 27

1.0 Introduction 29
1.1 Purpose 29
1.2 Version 30
1.3 Background 30
1.4 Developmental Approach/Assumptions 31

2.0 GIPS Engineering Extensions 36
2.1 The Existing GIPS 36
2.2 Baseline Engineering Extensions 36
2.2.1 ERIPS Baseline Engineering Extensions 36
2.2.2 ADRI Production Support Software Baseline Engineering Extensions 37
2.2.3 Production Database System Baseline Engineering Extensions 37
2.3 Multispectral/Radar Broad Area Imagery 38
2.3.1 Additional Sensor Capabilities - ERS-1/2 38
2.3.2 Additional Sensor Capabilities - IRS-1C 39
2.3.3 Additional Sensor Capabilities - RADARSAT 39

3.0 Candidate Mission Planning Products 40
3.1 Change Detection Product 40
3.2 Fusion Image Product 41
3.3 Terrain Categorized (TERCAT) Product 41
3.4 Vector Coverage Product 42

4.0 Hardware/Software Platforms 43
4.1 Product Testbed Platforms 43
4.2 Evaluation Platforms 43

5.0 Installation, Support, and Instruction 45
5.1 Installation 45

CONTENTS (Continued)

5.2 Support 45
5.3 Instruction 45

6.0 Timeline 46

7.0 References 47

Appendix A. Product Testbed Platforms 48
A.1 ERIPS (ERIM Remotely-Sensed Image Processing System) 48
A.2 MATRIX/MAGISTIC (MATRIX Geographic Information System and Turnkey Imagery Capability) 49
A.3 VITec ELT (Electronic Light Table) 50
A.4 TMWS (Target Materials Workstation) 50
A.5 ERDAS Imagine 51
A.6 SPECTRA (Standardized Production Environment for the Classification of Terrain and Resource Analysis) 52

FIGURES

1. GIPS Development Approach 32

2. GIPS Implementation Approach 34

3. New Product Development Cycle 35

4. GIPS Implementation Schedule 46

TABLES

1. Sensors Under Consideration for Inclusion in the GIPS Environment 31

2. Broad-Area Imagery and Mission Planning Product Matrix 33

ACRONYMS

ACC	Air Combat Command
ADRG	ARC Digitized Raster Graphic
ADRI	ARC Digital Raster Imagery
AFB	Air Force Base
AFMSS	Air Force Mission Support System
APG	Aim Point Graphic
ARC	Equal Arc-second Raster Chart/Map
C^3I	Command, Control, Communications, and Intelligence
CDPS	CMS Data Production System
CIB	Controlled Image Base
CIS	Common Intelligence System
CMPS	Common Mapping Production System
CMS	Common Mapping Standard
CPG	Common Product Generator
CVA	Change Vector Analysis
DMA	Defense Mapping Agency
DOD	Department of Defense
DTED	Digital Terrain Elevation Data
ELT	Electronic Light Table
EML	ERDAS Macro Language
EOD	Erasable Optical Disk
ERIM	Environmental Research Institute of Michigan
ERIPS	ERIM Remotely-Sensed Image Processing System
GCP	Ground Control Point
GGIPN	Global Geospatial Information Production Network
GIPS	Geocoded Imagery Production System
IG	Intelligence Group
IRS	Indian Remote Sensing
LISS	Linear Imaging Self Scanner
MACS	Mapping Applications Client/Server
MATRIX/MAGISTIC	MATRIX Geographic Information System and Turnkey Imagery Capability
MCG&I	Mapping, Charting, Geodesy, and Imagery
MIMES	Multispectral Imagery Materials and Exploitation System
MSI	Multispectral Imagery
MSS-II	Mission Support System
NITFS	National Imagery Transmission Format Standard

ACRONYMS (Continued)

PISCES	Production Image Screening and Change Editing System
RDBMS	Relational Data Base Management System
SAR	Synthetic Aperture Radar
SOM	Space Oblique Mercator
SPECTRA	Standardized Production Environment for the Classification of Terrain and Resource Analysis
SPOT	Satellite Pour l'Observation de la Terre
TERCAT	Terrain Categorized
TM	Thematic Mapper
TMFF	TM Fast Format
TMWS	Target Materials Workstation
USAF	United States Air Force
ZDR	Zone Distribution Rectangle

1.0 INTRODUCTION

The 480th Intelligence Group (IG), Langley Air Force Base (AFB), Virginia, has responsibility for the production of broad-area imagery to support Air Combat Command (ACC) mission planning. In addition to its role as the producer of broad-area imagery, the 480th IG has primary responsibility for database management of the Air Force Global Geospatial Information Production Network (GGIPN) as defined in the Concept of Operations for the Air Force Global Geospatial Information Production Network (draft, May 1994).

In support of these two areas of responsibility, the U.S. Air Force (USAF) and its Contractor, the Environmental Research Institute of Michigan (ERIM), recently installed the Geocoded Imagery Production System (GIPS) at the 480th IG to enable production of broad-area imagery in a standard USAF format. The USAF and ERIM also installed a GIPS Production Database System to enable the 480th IG to track USAF broad-area imagery production and to generate a catalog of the resulting broad-area imagery products. These two systems have been operational at the 480th IG since May 1995.

The GIPS currently produces broad-area imagery products in the ARC Digital Raster Imagery (ADRI) format. The specific mission planning product generated by the GIPS is known as the "Broad Area ADRI Product." At present, the GIPS input source imagery for the Broad Area ADRI Product is 10-meter Satellite Pour l'Observation de la Terre (SPOT) Panchromatic satellite imagery.

1.1 PURPOSE

The 480th IG is currently considering acquiring new kinds of sensor data and incorporating those data into the GIPS production environment for conversion into broad-area mission planning products. The 480th IG is specifically considering sensor data from four satellite systems:

1. the Landsat Thematic Mapper (TM),
2. the ERS-1 and ERS-2 radar systems,
3. the Indian Remote Sensing (IRS) IRS-1C system (launch expected late 1995), and
4. the Canadian RADARSAT system (launch date in September 1995).

Furthermore, the 480th IG is interested in developing and evaluating new kinds of mission planning products based on these new sources as well as the existing SPOT Panchromatic source. Examples of new mission planning products include Change Detection Products that enable analysts to locate new construction activities, and Terrain Categorized Products that help planners identify optimal drop zones.

This document describes a technical developmental roadmap for enhancing the GIPS with new sensors and mission planning products. The GIPS Roadmap presents:

1. a summary of the processes required to extend the GIPS functionality;
2. a discussion of candidate new mission planning products that might be developed from various sources of imagery, including any relevant products previously developed for the Department of Defense (DOD);
3. a summary of some of the potential hardware and software Product Testbed Platforms and Evaluation Platforms (and their limitations) that might be used to

develop new products and demonstrate the utility of the new sensors and products to the mission planning community;

4. a discussion of the instruction and support required to make effective use of any new capabilities within the 480th IG; and
5. a timeline for implementation.

1.2 VERSION

This is Version 1.0. It was produced for internal review within the 480th IG. This section will document significant changes as the USAF releases revisions.

1.3 BACKGROUND

In recognition of the utility of an unclassified, broad-area, and current database of imagery to support mission planning, the USAF, Rome Laboratory, and ERIM established the ADRI format and the first product in that format—the Broad Area ADRI Product. USAF mission planners use the Broad Area ADRI Products in mission planning and theater battle management systems as an image backdrop to assist mission profile development, the means to provide geopositioning information for navigation and target area acquisition, and a "real-world" scene for perspective view generation and mission preview.

The Broad Area ADRI Product is digital imagery transformed into the Equal Arc-second Raster Chart/Map (ARC) system and accompanied by ASCII encoded support files. Portions of one or more source images are orthorectified with Defense Mapping Agency (DMA) Digital Terrain Elevation Data (DTED), radiometrically balanced, and mosaicked into one-degree-by-one-degree Zone Distribution Rectangles (ZDRs). Broad Area ADRI is designed to be seamless, with adjacent ZDRs precisely abutting to provide contiguous coverage. The current source of Broad Area ADRI is SPOT Panchromatic imagery, although the USAF designed the Broad Area ADRI product specification to accommodate other kinds of imagery.

Broad Area ADRI must be transformed into the Common Mapping Standard (CMS) format for use on CMS-compliant systems such as the Mission Support System (MSS-II), the Air Force Mission Support System (AFMSS), and the Common Intelligence System (CIS). This conversion takes place within the CMS Data Production System (CDPS) environment. Other platforms within the DOD can ingest Broad Area ADRI directly without transforming it first to CMS-ADRI. In the near future, Broad Area ADRI data will be transformed into Controlled Image Base (CIB) using the Common Mapping Production System (CMPS). The CMPS will provide all the Mapping, Charting, Geodesy, and Imagery (MCG&I) data required as input to AFMSS and other Command, Control, Communications, and Intelligence (C^3I) systems.

Imagery sources from a number of spaceborne sensors exist as alternatives to the Panchromatic imagery from SPOT currently used in the production of Broad Area ADRI. Many of these sensors offer modalities not present in the SPOT Panchromatic system such as color sensing and all-weather capability. Imagery from other sensors offer similar capabilities to SPOT Panchromatic imagery, e.g., IRS-1C-Pan, but possibly at a lower cost. Table 1 presents a summary of the sensors currently being considered by the 480th IG. As previously suggested, the Broad Area ADRI product specification will accommodate each of these sensor data types.

Table 1. Sensors Under Consideration for Inclusion in the GIPS Environment

Sensor	Type	Spectral Bands	Spatial Resolution (m)	Nominal Ground Coverage (km^2)
Landsat TM	Multispectral	.45 - .52 µm	30	185
		.52 - .60 µm	30	"
		.63 - .69 µm	30	"
		.76 - .90 µm	30	"
		1.55 - 1.75 µm	30	"
		10.40 - 12.50 µm	120	"
		2.08 - 2.34 µm	30	"
IRS-1C				
LISS-III	Multispectral	.52 - .59 µm	23.5	142
		.62 - .68 µm	23.5	"
		.77 - .86 µm	23.5	"
		1.55 - 1.70 µm	70.5	148
PAN	Panchromatic	.50 - .75 µm	<10	70 (stereo capability)
ERS-1/2	Radar	5.6 cm (C-Band) V/V Polarization	12.5	100
RADARSAT	Radar	5.6 cm (C-Band) H/H Polarization	10	50 ("Fine")
			30	100 ("Standard")
			30	150 ("Wide")

1.4 DEVELOPMENTAL APPROACH/ASSUMPTIONS

This GIPS Roadmap outlines a developmental approach for bringing new sensors and new mission planning products on-line at the 480th IG. The approach will comprise three elements (labeled ❶, ❷, and ❸ in Figures 1 and 2 and in Table 2). These elements will take place on one or more hardware/software platforms resident at the 480th IG (labeled ①, ②, and ③ in Figure 1).

The first element involves a set of extensions to the existing GIPS environment at the 480th IG to effect functionality to geocode and mosaic imagery acquired by the new sensors in a manner identical to that used for geocoding SPOT Panchromatic imagery. The resulting product will be placed in the internal GIPS Broad Area Imagery format (❶). These extensions involve incorporating new sensor import routines, sensor geometric models, and database functions into the current GIPS environment as indicated in Figure 1 (①). Section 2.0 of the GIPS Roadmap describes these activities.

The second element involves expanding the available set of mission planning products beyond the existing single-band, single-sensor (i.e., SPOT) Broad Area ADRI Product. The approach taken will be to produce "prototype" products (❷). The 480th IG may create these prototype products in the GIPS environment or on some other "Product Testbed Platform" as indicated in Figure 1 (②). The first new mission planning product will be a relatively simple extension of the current Broad Area ADRI Product. Specifically, the new Broad Area ADRI Product will consist of multiband imagery from sensors other than SPOT. Section 2.0 also describes this first new product as it is a logical extension of the existing GIPS functionality. Section 3.0 of the GIPS Roadmap describes other candidate mission planning products.

The last of the elements involves performing evaluations (❸) of the new sensors and products by the 480th IG, ACC/DR, and USAF mission planners. These evaluations may take place in the GIPS environment, on the AFMSS, or on some other "Evaluation Platform" as indicated in Figure 1 (③).

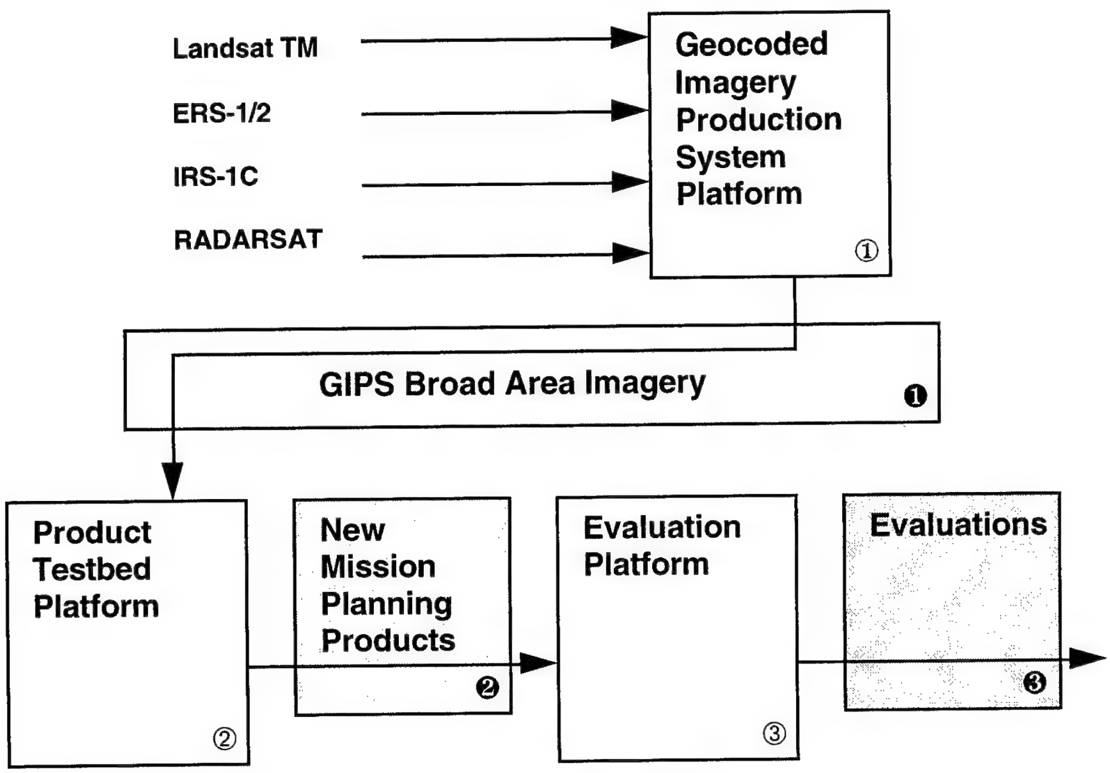

Figure 1. GIPS Development Approach

The new multiband, multisensor Broad Area ADRI Product will provide the format framework for all broad-area imagery produced by GIPS regardless of its source. Other new products may likewise be produced from any sensor, whereas some candidate mission planning products might only be suitable for a particular kind of sensor (e.g., a multispectral sensor). Table 2 conveys this concept for some of the candidate mission planning products introduced in Section 3.0.

Table 2. Broad-Area Imagery and Mission Planning Product Matrix

Candidate Mission Planning Products \ GIPS Broad Area Imagery	Landsat TM Broad Area Imagery ❶	ERS-1/2 Broad Area Imagery ❶	IRS-1C Broad Area Imagery ❶	RADARSAT Broad Area Imagery ❶
Multiband, Multisensor Broad Area ADRI Product ❷	√	√	√	√
Change Detection Product ❷	√	√	√	√
Terrain Categorized Product ❷	√		√	
Vector Coverage Product ❷	√	√	√	√

The 480th IG will use a phased approach to implementing new sensors and new mission planning products. Figure 2 diagrams the phased approach. The approach employs a "build a little, test a little" philosophy to bringing new sensors and new mission planning products on-line at the 480th IG. As each new sensor or product is introduced (the "build") at the 480th IG, it will undergo an evaluation (the "test") by the 480th IG, ACC/DR, and USAF mission planners. These Government evaluations will examine and assess the utility of the new sensor broad-area imagery or new mission planning product from the perspective of the mission planning process, and will provide critical user feedback to the product development cycle.

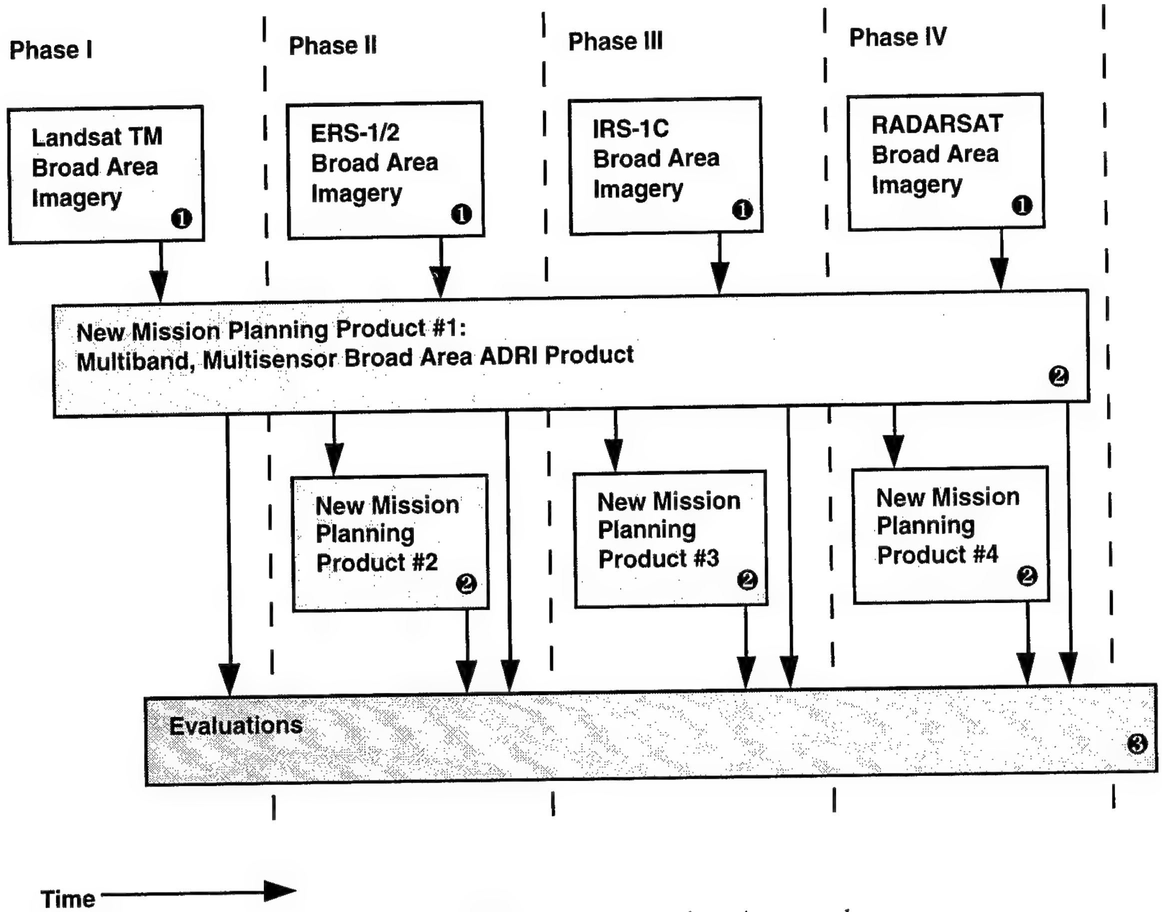

Figure 2. GIPS Implementation Approach

In a manner similar to the development of the original SPOT Panchromatic Broad Area ADRI Product in the early 1990s, each new product will go through a three-stage development cycle. Figure 3 illustrates this cycle and identifies key features of each Stage. In Stage I of product development, the developer designs a new product to address specific user needs, and builds a prototype of that product using available software tools. In Stage II, the developer performs a feasibility, or pilot, demonstration. In this middle stage, the developer generates a relatively small sample of the product for purposes of defining eventual production requirements and specifying interface requirements (using Interface Control Documents) between different systems. The developer also uses this Stage of the development cycle to obtain vital user evaluations. A product may undergo significant revisions, or possibly abandonment, at this stage as a result of user feedback, production limitations, or other factors. Only those products worthy of operational implementation achieve Stage III. In this final Stage, production systems are developed or tailored for full-scale production of the new product. This GIPS Roadmap will address activities related to the development of new products only through Stage II of this development cycle (Pilot Production).

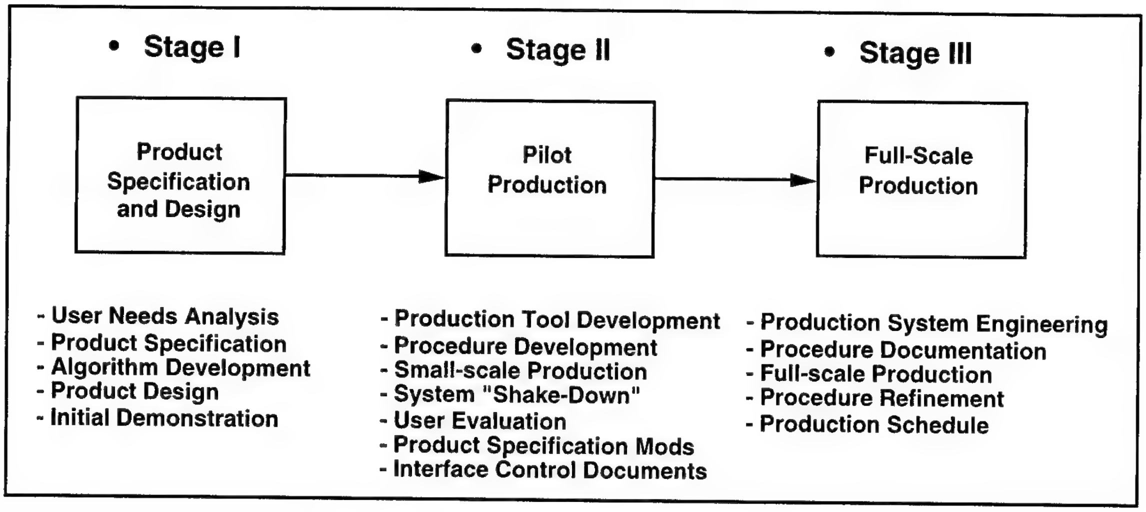

Figure 3. New Product Development Cycle

The following assumptions form the basis of this GIPS Roadmap:

1. Conversion of each new source of imagery into broad-area imagery (geocoding and mosaicking) will take place in the existing GIPS software and hardware environment.
2. The first new sensor to be added to the GIPS environment will be Landsat TM.
3. Samples of the new sensor sources will be obtained by the 480th IG using normal commercial channels.
4. The first new mission planning product will be a multiband (i.e., Landsat TM) Broad Area ADRI Product. By implementing this product first, the 480th IG will establish the necessary product framework for all subsequent broad-area imagery products (ERS-1, IRS, RADARSAT, etc.), i.e., a multiband, multisensor Broad Area ADRI Product. This implementation will occur in the existing GIPS software and hardware environment.
5. All other new mission planning products will be produced to the ADRI format specification.
6. The 480th IG will produce and evaluate all other new mission planning products within the most practical software and hardware environment present at its facility. This strategy will minimize overall new product development costs; however, instruction costs may be higher than if the 480th IG used a single software and hardware environment.

2.0 GIPS ENGINEERING EXTENSIONS

This section describes the system engineering extensions required to the GIPS to support new sensors and the multiband, multisensor Broad Area ADRI Product.

2.1 THE EXISTING GIPS

GIPS is composed of three components:

1. ERIM's Remotely-Sensed Image Processing System (ERIPS 3.0)
2. ADRI Production Support Software
3. Production Database System Software

ERIPS 3.0 is used in the GIPS for specific image processing tasks such as data loading, control point selection, block adjustment, radiometric balancing, orthorectification, and mosaicking.

The modules of the ADRI Production Support Software are applications written specifically for the production of the Broad Area ADRI Product. The software is written using the ERIPS Callable Service utilities and provides applications to generate accuracy assessments, generate Broad Area ADRI Overview Images, and produce the final Broad Area ADRI Volumes.

The Production Database System is a database inventory and production tracking system built using the Oracle Relational Data Base Management System (RDBMS) and forms. It provides utilities to load source image, DTED, ground control point (GCP), and Broad Area ADRI Volume metadata into the database. It also provides text and graphical reports to aid in the production of Broad Area ADRI.

2.2 BASELINE ENGINEERING EXTENSIONS

Extensions to the three GIPS software components are necessary for Broad Area ADRI production from other than SPOT source imagery. Extensions to certain basic capabilities must be made to handle multiband data and non-SPOT source imagery (particularly in the ADRI Production Support Software and in the Production Database System). Once these initial extensions are made, the introduction of new sensors to the software will entail revisiting key functions, such as Data Loading/Importing and the Sensor Model.

This section describes the engineering extensions required to modify the GIPS software components for multiband data using Landsat TM source imagery as the baseline sensor.

2.2.1 ERIPS Baseline Engineering Extensions

ERIM is already making engineering extensions to ERIPS to support geometric processing of Landsat TM data. This new version, called ERIPS 4.0, will support data loading and a new Sensor Model for Landsat TM data. With this new release, the ERIPS display utilities and applications will complete the support of multiband data, thus facilitating integration of future multispectral sensors into ERIPS.

ERIM will release ERIPS 4.0 in the Fall 1995.

2.2.2 ADRI Production Support Software Baseline Engineering Extensions

The ADRI Production Support applications, Accuracy Assessment, Overview Image Creation, and ADRI Final Product (Volume) Creation must be upgraded for multiband data. These applications use ERIPS display utilities and callable service routines which will be upgraded for ERIPS 4.0, allowing for the display and processing of multiband imagery. The ADRI capabilities will be extended to use the full complement of ERIPS 4.0 utilities. Other extensions must be made to the Overview Image Creation and ADRI Final Product Creation applications to conform to the 17 October 1994 draft of the Broad Area ADRI Product Specification developed by Rome Laboratory that was written to accommodate sensors other than SPOT.

2.2.3 Production Database System Baseline Engineering Extensions

Five different aspects of the Production Database System require extensions to accommodate future growth. These five aspects are:

1. <u>System Flexibility</u>: The Production Database System requires upgrades to support different sensors and metadata information. The current system supports importing of SPOT Level 1A data. The database will be modified to support different metadata fields based upon sensor type. This requires extensions to the Importing Source Image Metadata applications and the Query/Display forms. The approach implemented will take advantage of loading common fields (such as corner latitudes and longitudes of the image) and sensor specific fields (such as viewing angle for SPOT 1A or polarization for ERS-1/2). The system will be flexible where adding a new sensor will entail only revisiting the list of specific fields for a sensor and developing specific user interface forms and reports for displaying those specific fields.
2. <u>Source Material Code/Volume Edition Support</u>: The current Production Database System limits the identification of a Broad Area ADRI Volume (the final Broad Area ADRI product) by Volume ID (a five-digit number) and Volume Edition (1-99). The introduction of new source data into the system requires a change in the unique identification to consist of the Volume ID, Volume Edition, and Source Material code (a Broad Area ADRI Volume cannot contain more than one unique source material code). Source Material codes are a two-character code intended to designate the type of raw source imagery used in the product.
3. <u>ORACLE Upgrade</u>: To take advantage of new features and to support the flexible approach desired for adding new sensors, the 480th IG will upgrade the GIPS to ORACLE 7/Forms 4. GIPS is currently using ORACLE 6/Forms 3. The upgraded ORACLE would provide a windows user interface, as opposed to a character-based interface as is Forms 3. Windows or overlays would easily be created displaying common and sensor specific metadata. In addition to taking advantage of the new features of ORACLE 7, ORACLE 6 is no longer a supported version.
4. <u>Chip Library Upgrade</u>: The GIPS Chip Library system allows operators to maintain a library of ground control image chips on Erasable Optical Disks (EODs). The Chip Library system requires extensions to maintain the type of

image data from which the chip was created. Chip Library image display utility (part of GIPSPlot) also requires extensions for the additional image types.

5. ADRI Catalog Application: The ADRI Catalog is a document showing plots and providing metadata listings of Broad Area ADRI final products. The document is created using tools from the Production Database System and the Mapping Applications Client/Server (MACS). A Broad Area ADRI Volume is read, extracting a pseudo-source map containing image and non-image data. The pseudo-source map is then used to create vector plots of the Broad Area ADRI Volume and its cells. Extensions to the utilities to import and export ADRI Volume Metadata would be required to support the new Volume identification schema for source material codes. Extensions would also be required in the reading of the Broad Area ADRI Volume to support multiband data.

2.3 MULTISPECTRAL/RADAR BROAD AREA IMAGERY

Data acquired by any of the four new sensors may be geocoded, orthorectified, and mosaicked for purposes of generating highly accurate geographic databases of broad-area imagery. A small region of interest can be processed, or if the area of interest exceeds the bounds of a single image, multiple images can be mosaicked together. With respect to Landsat TM and IRS-1C, these can be generated using standard three-band composites, the bands of which an analyst selects to enhance particular features in the image. Spatial filtering can be applied to enhance image detail. With respect to ERS-1/2 and RADARSAT, a number of algorithms can be applied to enhance data utility including speckle reduction and edge enhancement.

These sources of broad area imagery can serve a wealth of applications including precision positioning, updating and verifying collateral map sources, broad-area search, area limitation, precision mapping (facilities, airports, lines of communication, etc.), and input to flight rehearsal systems. With respect to flight rehearsal, the availability of color with sensors such as Landsat TM and IRS-1C enable the generation of more realistic looking terrain, thus enhancing utility. Synthetic Aperture Radar (SAR) imagery from ERS-1/2 and RADARSAT provides a source of data with day/night and all-weather capabilities. These capabilities are particularly important for analysts and planners trying to acquire usable imagery in the Equatorial Zones and at high latitudes. SAR systems also provide a source of broad-area imagery for high-fidelity airborne SAR simulations. Broad-area imagery may also be used for cueing other higher resolution assets.

With each new sensor addition to GIPS, three key functions must be extended: Data Loading, Metadata Importing, and Sensor Model Polynomial Generation. The following descriptions assume that the extensions to ERIPS, the ADRI Production Support Software, and the Production Database System described in Section 2.2 have already taken place.

2.3.1 Additional Sensor Capabilities - ERS-1/2

For ERS-1/2 the following approach will be taken:

Data Loading: ERS-1/2 data are available on magnetic tape (9-track or 8-mm tape). The ERIPS Data Load application will be modified to read metadata and image data and format the data for ERIPS. The Data Load application will compress the 16-bit format into 8 bits in order to support eventual display on AFMSS.

Metadata Importing: Similar to Data Load, the Production Database System metadata import application will be modified to allow for import of common image metadata and metadata specific to ERS-1. An import and several query/update user interface forms will be created, listing the specific ERS-1/2 fields desired.

Sensor Model Generation: The ERIPS Control application will be modified to incorporate an ERS-1/2 sensor model.

2.3.2 Additional Sensor Capabilities - IRS-1C

For IRS the following software approach will be taken:

Data Loading: IRS-1C data will be available on magnetic tape (9-track or 8-mm tape). Minimal effort will be required to upgrade ERIPS to support loading of IRS data because the data format is similar to TM Fast Format (TMFF), i.e., path-oriented and resampled to the Space Oblique Mercator (SOM) projection.

Metadata Importing: Likewise, the Production Database System metadata import application can take advantage of the existing modules and forms to import TMFF. Minimal effort will be required to incorporate this sensor type.

Sensor Model Generation: The ERIPS Control application will be modified to incorporate an IRS-1C sensor model.

2.3.3 Additional Sensor Capabilities - RADARSAT

For RADARSAT the following software approach will be taken:

Data Loading: Similar to ERS-1/2, RADARSAT is formatted to 16 bits. To support display on AFMSS, the Data Load application will compress the data to 8 bits. The RADARSAT format is similar to ERS-1/2 format requiring minimal effort to upgrade ERIPS.

Metadata Importing: Similar to Data Load, the metadata import application will be modified to allow for import of common image metadata and metadata specific to RADARSAT. An import and several query/update user interface forms will be created, listing the specific RADARSAT fields desired. The RADARSAT format is similar to ERS-1/2 format requiring minimal effort to upgrade the Production Database System.

Sensor Model Generation: The ERIPS Control application will be modified to incorporate a RADARSAT sensor model.

3.0 CANDIDATE MISSION PLANNING PRODUCTS

The integration of multispectral (MSI) and radar image data into the GIPS significantly enhances the potential for the development of new kinds of products to support mission planning. With respect to MSI, the increased spectral resolution of the Landsat TM and IRS-1C sensors vastly improves the potential for terrain feature discrimination, both automatically and manually. The radar data to be provided by the ERS-1/2 and RADARSAT platforms also improve the potential for geopositioning and high-resolution terrain analysis. Additionally, these data sources may be used to effect the development of derived products such as vector overlays and hybrid data sets such as fusion images.

This section describes several candidate mission planning products that the 480th IG could produce, demonstrate, and evaluate.

3.1 CHANGE DETECTION PRODUCT

Change detection products are generated using multispectral or radar image data and, in general, are formed by overlaying data covering the same terrain acquired at two different times. The amount of processing required to generate this product can vary depending on the amount of information desired and various time constraints. Three types of products discussed here include: (1) simple two-channel, (2) two-channel with feature screening, and (3) Change Vector Analysis.

<u>Simple Two-Channel</u>. The most basic product can be generated by overlaying a specific spectral band from two dates. This can be done relatively quickly and is very effective at revealing the existence of changes. Typically, the first date is projected in blue and green, and the second date is projected in red; objects brighter on the second date appear in red while objects brighter on the first date appear in cyan. With additional processing time, a spectral feature can be computed for both dates and overlaid to form the change image. A spectral feature is a linear combination of two or more bands of multispectral data designed to enhance particular image features. For example, features have been developed that enhance the difference between vegetated terrain and cleared land. This product can be displayed on a three-channel system by replicating the first date information in blue and green and assigning the second date information to red.

<u>Two-Channel with Feature Screening</u>. As an augmentation to the Simple Two-Channel change image, one or more image features such as vegetation, clouds, and cloud shadow can be screened out to minimize potential confusion in interpreting change images. ERIM has developed and delivered to two sites a system referred to as the Production Image Screening and Change Editing System (PISCES) that employs scene-to-scene registration, computation of spectral features, and screening of second-date vegetation, clouds, and cloud shadows. This is a three-channel product produced using Landsat TM.

Both Two-Channel change detection products have proven useful for broad-area search and bomb damage assessment. They are particularly effective for detecting facilities and road construction, lengthening of airport runways, movement of supplies, and construction of missile sites. They may also be used to assist in cueing other higher-resolution assets.

Change Vector Analysis. A more sophisticated approach to change detection can be effected through use of a technique referred to as Change Vector Analysis (CVA). With CVA, a change vector is produced from a multidate set of either raw input bands or linear combinations such as physically-based transforms (e.g., Tasseled-Cap Components).

A change vector is characterized by a direction and magnitude; the direction describes the nature of the change while the magnitude describes the intensity of the change. The benefit of this method is that it can reveal information related to the types of changes detected, particularly when applied with physically-based transforms. This is unlike the previous two methods discussed which only reveal whether or not a change has occurred. However, while CVA can stratify different types of changes, the analyst must still label those changes (much like *a posterior* labeling of a categorized image—see Section 3.3).

A CVA image typically consists of a single band (or spectral feature) as a backdrop with the different change categories color-coded and superimposed. This product can be very useful for long-term monitoring as it has the potential of stratifying different types of activities. For example, it is conceivable that CVA could separate facilities construction, clear-cutting, and mining all as unique types of changes. A CVA image can also be used for updating and verifying collateral map sources, precision geopositioning, and cueing other higher-resolution assets. This is a three-channel product.

3.2 FUSION IMAGE PRODUCT

Typically, a Fusion Image is generated through the merging of a lower-resolution multispectral image with a higher-resolution panchromatic or radar image. The intent is to produce an image that retains the benefits of multispectral data while also incorporating the benefits of higher resolution panchromatic/radar image data. Several potential fusion combinations include:

MSI	Sharpening Channel
Landsat TM	SPOT Pan
Landsat TM	IRS-1C/Pan
Landsat TM	ERS-1, 2
Landsat TM	RADARSAT
IRS-1C MSI	IRS-1C/Pan
IRS-1C MSI	ERS-1, 2
IRS-1C MSI	RADARSAT

Fusion Image Products are useful for precision geopositioning, updating and verifying collateral map sources, and precision mapping (facilities, airports, lines of communication, etc.). This is the only image product that affords the unique benefit of simultaneously permitting multispectral feature discrimination and high-resolution spatial discrimination.

3.3 TERRAIN CATEGORIZED (TERCAT) PRODUCT

This is an MSI-derived product generated through a process known as multispectral classification. In this case, terrain features are assigned to discrete categories using either an unsupervised or supervised procedure. For unsupervised classification, an algorithm is applied to the entire image that identifies homogeneous groups of spectral signatures according to various statistical criteria; labeling of the groups computed is handled *a*

posterior. For supervised classification, an analyst manually selects image data samples (i.e., signatures) of known terrain type and uses an algorithm to match these with all pixels in the image. TERCAT Products may consist of data from one image, or may be a mosaic of several images. Radar data may be used to assist in the classification process, particularly with the feature labeling process.

TERCAT Products are typically provided as one-byte image files and are assigned colors interactively on the display system according to a color look-up-table. These images can also be converted to three bytes so that the image appears in color on a standard red/green/blue display.

This type of product has been used extensively for area limitation applications. Knowledge of terrain type relates directly to understanding trafficability and concealment, both of which are key to area limitation. TERCAT Products, often used in conjunction with broad-area imagery, may also be used for planning ingress/egress routes, rescue and evacuation planning, intelligence preparation of the battlefield, and general land use mapping.

3.4 VECTOR COVERAGE PRODUCT

Vector coverages can be extracted for virtually any purpose and overlaid on top of the image products described above. These can be displayed in a graphics channel on the display system. Examples of vector coverage applications include:

1. Lines of communication digitized from broad-area imagery to assist in ingress/egress planning and area limitation.
2. Missile sites identified and annotated on a broad-area Radar image; these annotations can be transferred to a multispectral image, or, can be used to rapidly update a target database.
3. Polygon outlines of water bodies and wetlands compiled using a TERCAT Product, and then superimposed on broad-area imagery to assist in demarcating drop zones.
4. Symbols, outlines, and other markings highlighting new construction generated from a Change Detection Product and then used to update an activities database.

In fact, specific products and procedures can be developed using vector coverages in conjunction with the products described above.

4.0 HARDWARE/SOFTWARE PLATFORMS

The 480th IG will produce and evaluate the new mission planning products within the most practical software and hardware environment present at its facility. This strategy will minimize overall new product development costs. The following two subsections identify potential Product Testbed Platforms and Evaluation Platforms, respectively.

4.1 PRODUCT TESTBED PLATFORMS

There are a number of Product Testbed Platforms with the potential of demonstrating generation of the prototype mission planning products described in Section 3.0. However, native capabilities vary significantly from platform to platform and, in some cases, additional development would be required to bring a platform to the appropriate level for this effort. Some of these platforms are resident at the 480th IG or might be under consideration for installation. These platforms include: ERIPS, MATRIX Geographic Information System and Turnkey Imagery Capability (MATRIX/MAGISTIC), VITec Electronic Light Table (ELT), Target Materials Workstation (TMWS), ERDAS Imagine, and Standardized Production Environment for the Classification of Terrain and Resource Analysis (SPECTRA). The discussion in Appendix A represents ERIM's current best understanding of these systems.

ERIM's software library contains algorithms to support all of the products listed in the section above entitled Candidate Mission Planning Products. To incorporate these products into the GIPS, ERIM could provide a consistent user interface similar to the existing GIPS thereby reducing the instruction effort required if other testbed platforms are used.

4.2 EVALUATION PLATFORMS

Any of the new mission planning products could be displayed and evaluated on the same Product Testbed Platform that is used for developing the prototype products. The deficiency in employing such a strategy is that the products would not be evaluated in the mission planning environment (i.e., MSS-II or AFMSS) that is familiar to the mission planning community.

ERIM has held preliminary discussions with Lockheed Sanders regarding an approach that could be taken to display all the new products on the AFMSS. The advantage of this approach is that new mission planning products can be demonstrated and evaluated by mission planners in the environment with which they are comfortable and where they will have access to all the other software tools they use in the mission planning process.

The approach discussed with Lockheed Sanders would involve no changes to the CDPS or CMPS systems and only minor changes to the display server used in AFMSS. The approach involves splitting any colored, multiband product into individual, single-band components, converting those components through CDPS or CMPS, and then reconstituting the colored, multiband product on the AFMSS. Thus a colored mission planning product such as three-band Landsat broad-area imagery, would be produced as both a true multiband Broad Area ADRI Product (which can be read by systems such as ERDAS Imagine), as well as three individual single-band Broad Area ADRI Products.

Formatting the multiband mission planning products as single-band Broad Area ADRI Products will allow the products to pass through the CDPS or CMPS conversion process for display on AFMSS.

5.0 INSTALLATION, SUPPORT, AND INSTRUCTION

5.1 INSTALLATION

The 480th IG will implement the required extensions to the existing GIPS environment for the new sensors in such a manner as to have minimal impact on the SPOT Broad Area ADRI Product production line. The 480th IG will upgrade the GIPS software on only one of the four GIPS Sparc20 workstations, or it will acquire a fifth Sparc20 workstation. The latter approach will permit the 480th IG to maintain maximum throughput capacity for the SPOT Broad Area ADRI Product while generating the new mission planning products.

Each new sensor capability will be brought on-line at the 480th IG as the extensions to GIPS for that sensor become available allowing for a phased approach to implementation and evaluation.

Likewise, each new mission planning product will be brought on-line at the 480th IG as the prototype procedures and software tools for that product become available. This allows for a phased approach to implementation and evaluation of the new mission planning products as well.

5.2 SUPPORT

The 480th IG will require contractor support to help develop the specific prototype mission planning products. This contractor support will take place at the contractor's facility and at the 480th IG. Referring to Figure 3, the majority of Stage I product design activities and the Stage II production procedure and tool development activities will take place at the contractor's facility. Once these pilot production tools are installed at the 480th IG, the contractor will provide continuous on-site support to the 480th IG to help institute the pilot production for that product.

The 480th IG will coordinate product reviews and evaluations by key individuals at Langley AFB and USAF mission planners.

5.3 INSTRUCTION

The 480th IG will require contractor support to provide operator instruction in the production of broad-area imagery from the new sensors. All instruction will take place at the 480th IG.

The 480th IG will require contractor support to provide operator instruction in the production of the new mission planning products. All instruction will take place at the 480th IG.

The instruction will be phased with the installation of new sensor capabilities and new mission planning products. The contractor will provide production procedures identifying any revisions to the existing ADRI Production Procedures for the new sensors. The contractor will also provide production procedures for generating the new mission planning products on the Product Testbed Platform.

6.0 TIMELINE

Figure 4 presents a timeline for implementation of new sensors and mission planning products at the 480th IG.

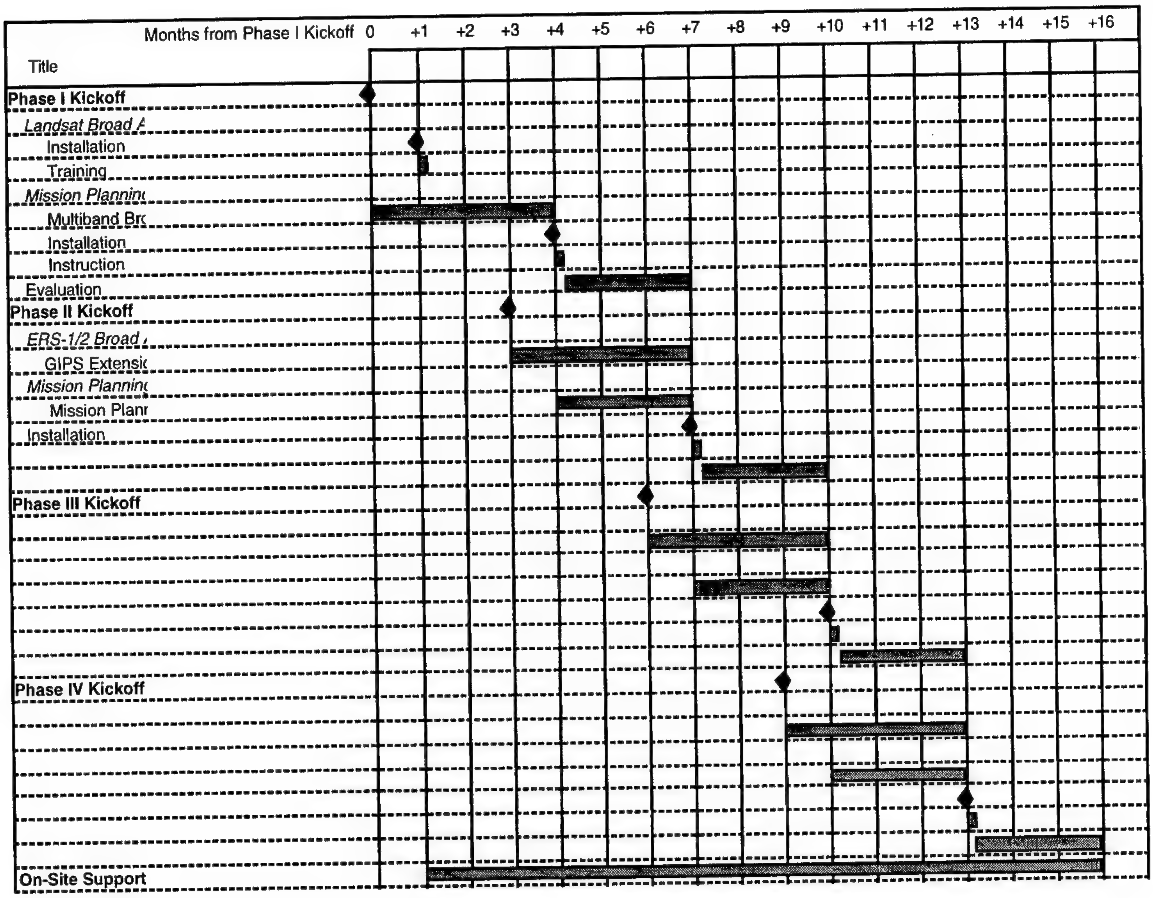

Figure 4. GIPS Implementation Schedule

7.0 REFERENCES

Electronic Systems Center, Military Specification ARC Digital Raster Imagery (ADRI) Format, MIL-A-89027, 24 July 1992.

Electronic Systems Center, Military Specification Broad Area ARC Digital Raster Imagery (ADRI) Product, MIL-B-89031, 24 July 1992.

Environmental Research Institute of Michigan, ERIPS, The ERIM Remotely-Sensed Image Processing System Software User's Guide, V3.0, January 1995.

NAIC/480 Intelligence Group, Concept of Operations for the Air Force Global Geospatial Information Production Network, Version 1.1(draft), 24 May 1994.

Rome Laboratory, Military Specification Broad Area ARC Digital Raster Imagery (ADRI) Product, draft dated 17 October 1994.

SPOT Image Corporation, SPOT User's Handbook, Version A.A, Rev 4, April 1989.

APPENDIX A. PRODUCT TESTBED PLATFORMS

A.1 ERIPS (ERIM REMOTELY-SENSED IMAGE PROCESSING SYSTEM)

Developed by: The Environmental Research Institute of Michigan

ERIPS is a system developed and maintained by ERIM. It is uniquely designed to address requirements associated with large-area mosaicking. ERIM has delivered ERIPS to the 480th IG at Langley AFB. ERIPS is also the image processing platform in the Eagle Vision Data Integration Segment. ERIPS 4.0 enables geometric processing and orthorectification of SPOT 1A and Landsat TM image data through use of satellite platform models and block adjustment techniques. ERIPS 4.0 capabilities include:

Data Input ... Loading of SPOT XS and Pan, Landsat TM (Fast Format).

Image Repair ... Interactive capability that enables repair of bad scan lines, or "glitches."

Histogram ... Generation of image histograms.

Chip Preparation ... Extraction of 511x511 image chips used in the process of computing geodetic control information.

Control Point ... Selection of control points and tie points, platform attitude correction, block correction/polynomial computation, and polynomial evaluation for SPOT 1A and Landsat TM data.

Resample ... Restoration resampling and geocoding/orthorectification of SPOT 1A and Landsat TM data.

Radiometric Balancing ... Interactive adjustment of the radiometry of multiple images.

Mosaicking ... Digital "stitching" and feathering of geocoded/orthorectified image data.

Geographic Mensuration ... Mensuration and storage of geographic control points from geocoded image data.

Spatial Filtering ... Boxcar filtering and edge-enhancement utilities.

Image Math ... Mathematical operations that can be performed on image data.

Image Display ... Flexible display utility that provides a series of interactive capabilities including contrast enhancement, zooming, panning, etc. Up to 12 images can be placed in a single display window.

Currently, ERIPS does not have the capability to perform change detection or terrain categorization. However, algorithms and procedures installed with the Multispectral Imagery Materials and Exploitation System (MIMES) at Offutt AFB in Omaha, Nebraska*, could be migrated to ERIPS to fulfill requirements for two-channel change detection (with and without feature screening) and terrain categorization. The CVA algorithm is installed at ERIM's facility and could also be migrated. These techniques have been operational for many years and are well understood; the methods in place at

MIMES have been customized to specifically address the needs of the intelligence and mission planning communities.

*MIMES is a multispectral processing and production facility designed and supported by ERIM. It has been operational since 1988.

A.2 MATRIX/MAGISTIC (MATRIX GEOGRAPHIC INFORMATION SYSTEM AND TURNKEY IMAGERY CAPABILITY)

Sponsored by: U.S. Government

System Integrator for MAGISTIC: GeoDynamics

The MATRIX system is a well-known Government-sponsored system originally designed to address processing and analysis requirements associated with radar image data. Over the last several years, it has grown to include a suite of multispectral processing capabilities. MAGISTIC represents the core multispectral capability for MATRIX.

MAGISTIC includes the following modules:

Tiered Product Generation ... Quick printing of selected regions of Landsat TM images.

Coregistration ... Automated/semi-automated scene-to-scene registration of raw Landsat TM images.

Common Product Generator (CPG) ... Generation of standard image products for Landsat TM and, in some cases, SPOT image data. It is modeled after the MIMES capability at Offutt AFB. Products include Analysis Image (TM, SPOT), Change Image (TM), Geocoded Pan (SPOT Pan), Ground Control Chip (TM, SPOT), Image Graphic (TM, SPOT), Mosaic Image (TM, SPOT), Perspective View (TM, SPOT), TERCAT Image (TM, SPOT XS), and TERCAT Mosaic (TM, SPOT XS).

Multispectral In-Scene Normalization ... Capability to radiometrically normalize Landsat TM image data (bands 1-5,7) in ERDAS 8.x format.

Mystic TERCAT ... Multispectral categorization of Landsat TM data using a Genetic Algorithm.

The Change Image product is generated using the MATRIX module known as the Production Image Screening and Change Editing System (PISCES), originally developed by ERIM; this can generate products equivalent to the two-channel change detection products described above. All geocoding is accomplished by standard "rubber-sheeting" (basic multiple linear regression); satellite platform models are not used. Orthorectification is not possible.

Note that CPG is a shell built directly over ERDAS Imagine; see the discussion of ERDAS Imagine for details.

Other capabilities developed as parts of MATRIX/MAGISTIC include Change Significance Analysis, Automated Lines of Communication, Atmospheric Correction,

and Image Sharpening; ERIM is not currently aware of the details. MATRIX/MAGISTIC is currently installed at the MIMES facility at Offutt AFB.

MAGISTIC does not permit processing of radar data. While MATRIX includes a number of radar processing techniques, ERIM does not believe it permits geometric processing (geocoding/orthorectification) of radar imagery.

A.3 VITEC ELT (ELECTRONIC LIGHT TABLE)

Developed by: Connectware

VITec ELT is an image processing system with a strong niche in the Airborne Reconnaissance community. It is designed to address all three phases of exploitation. It currently only supports single-band processing, but can easily be upgraded to fully support full color (24-bit) processing. ELT includes a basic set of image display tools, but can be augmented with a series of optional modules including:

ELT Register ... Image-to-image warp by manual control point selection; an automated procedure is reportedly in work. Facilitates basic change detection processing.

ELT ADRG ... Ingest and manipulation of ARC Digitized Raster Graphic.

ELT NITFS ... Bridge to National Imagery Transmission Format Standard files.

ELT Roam .. With the ViTEC Viper upgrade, enables high-speed roaming of large images (60fps for one-channel images).

ELT Ruler ... Image mensuration capability.

ELT Toolkit ... Enables integration of external capabilities and user interface customization.

ELT currently does not include geometric correction (model or non-model), terrain categorization, or explicit change detection. However, this system is continually evolving, so ERIM may not be fully aware of new capabilities currently under development.

A.4 TMWS (TARGET MATERIALS WORKSTATION)

Sponsored by: U.S. Government
Developed by: GeoDynamics

TMWS is designed primarily to generate products analogous to Aim Point Graphic (APG) cards using panchromatic and multispectral imagery. This includes a TMWS User Interface and Production Manager, Mensuration Module, CalComp Image Scanning Module, TMWS Archive, NITF Level 2 Protocol, and Answerbook. It does not include model-based geometric correction, nor explicit change detection. It is built directly on ERDAS Imagine, thus enabling access to a broad base of image processing capabilities; see the discussion of ERDAS Imagine for details. As of October 1994, the ERDAS

Imagine components provided with TMWS were to include: Viewer, Import/Export, Map Composer, Utilities, and Image Interpreter.

TMWS is currently installed at the MIMES facility at Offutt AFB.

A.5 ERDAS IMAGINE

Developed by: ERDAS Inc.

ERDAS Imagine is the most widely distributed and accepted commercial processing system available, due mostly to its breadth of mature image processing tools. It has a very large customer base and is found in both the defense and civilian sectors. A number of different components are available with Imagine. These include:

Viewer ... Image display utility and associated functions.

Import/Export ... Import and export for a variety of data types.

Map Composer ... Generation of fully annotated image graphics and hard copy output.

Utilities ... Includes viewing of image statistics, projection information, and map information.

Rectification ... Geocoding of image data using the standard "rubber-sheeting" method.

Image Interpreter ... Image processing functions including spatial, spectral, and radiometric enhancement, frequency domain processing, and geographic information system utilities.

Classification ... Tools for supervised and unsupervised classification of multispectral data.

Spatial Modeler ... Generation of custom procedures using ERDAS-provided functions and, if desired, external applications (requires Developer's Toolkit).

Image Catalog ... Data management system. Allows for queuing, archiving and retrieval of images.

Vector ... Creation and editing of vector layers.

Radar ... Includes several radar processing tools for data handling, speckle noise removal, and image enhancements. Tools are not currently available for geometric processing.

Perspective View ... Three-dimensional perspective view generation.

AutoWarp ... Automatic scene-to-scene warping.

Restoration ... Resampling using the restoration technique developed by ERIM.

OrthoMax ... Enables extraction of elevation data from digital stereo pairs and orthorectification of digital image data. Employs a camera model.

Precision Geocoding ... Platform model-based geometric correction technique for Landsat TM; this is applied on a single-scene basis (does not permit block correction). This is the TM model originally developed by ERIM.

Developer's Toolkit ... Utility that enables the development and integration of external applications in Imagine.

ERDAS Imagine is continually evolving and new modules are under development. This is a large system organized on a purely functional basis. The end-user can create and modify user interfaces using EML (ERDAS Macro Language) and add external applications using the Developer's Toolkit.

A.6 SPECTRA (STANDARDIZED PRODUCTION ENVIRONMENT FOR THE CLASSIFICATION OF TERRAIN AND RESOURCE ANALYSIS)

Sponsored by: U.S. Government

Developed by: Intergraph

SPECTRA is a Government-sponsored image processing system that enables generation of standard image products for Landsat TM and SPOT. It is modeled after the MIMES capability at Offutt AFB. This is built on proprietary Intergraph hardware using VITec raster imagery processors and the UNIX operating system. Standard products include Analysis Image, Change Image/Reference Image, Ground Control Chips, Image Graphic, Mosaic Image, Terrain Categorization (TERCAT), TERCAT Mosaic, and Perspective View.

The Change Image module is actually a version of the Production Image Screening and Change Editing System (PISCES), originally developed by ERIM; this can generate products equivalent to the two-channel change detection products described above. All geocoding is accomplished using satellite platform models and mosaics are generated using a rigorous block adjustment technique. Orthorectification can be performed. Categorization can be performed using both supervised and unsupervised classification techniques.

This system is currently installed at the Defense Intelligence Agency in Washington, D.C. It was installed at the MIMES facility at Offutt AFB, but has since been returned to the developer.

☆U.S. GOVERNMENT PRINTING OFFICE: 1997-509-127-47093

MISSION

OF

ROME LABORATORY

Mission. The mission of Rome Laboratory is to advance the science and technologies of command, control, communications and intelligence and to transition them into systems to meet customer needs. To achieve this, Rome Lab:

a. Conducts vigorous research, development and test programs in all applicable technologies;

b. Transitions technology to current and future systems to improve operational capability, readiness, and supportability;

c. Provides a full range of technical support to Air Force Materiel Command product centers and other Air Force organizations;

d. Promotes transfer of technology to the private sector;

e. Maintains leading edge technological expertise in the areas of surveillance, communications, command and control, intelligence, reliability science, electro-magnetic technology, photonics, signal processing, and computational science.

The thrust areas of technical competence include: Surveillance, Communications, Command and Control, Intelligence, Signal Processing, Computer Science and Technology, Electromagnetic Technology, Photonics and Reliability Sciences.